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Rochester Institute of Technology

College of Liberal Arts

Department of Psychology

IDENTIFYING MEDICAL RESIDENT STRESS WITH WORK DOMAIN REPRESENTATION

By

Daniel Travis Nystrom

A Thesis in

Applied Experimental and Engineering Psychology

Submitted in partial fulfillment of the requirements for the degree of

Master of Science

May 17, 2013

We approve the thesis of Daniel Travis Nystrom:

Esa Rantanen, Ph.D

Date

Associate professor at RIT, Mentor

Faculty Adviser and Chair of the Thesis Committee

Gavan Lintern, Ph.D

Date

Cognitive Systems Engineer, Mentor

Reader

Anthony Fedullo, MD

Date

Director of Medical Education, Research collaborator

Reader

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Abstract

Resident physicians must endure substantial amounts of stress to acquire the necessary skills and knowledge to become competent, certified physicians. Multiple factors that contribute to high levels of stress in different areas of the healthcare domain have been identified, but stress continues to be a major problem despite this knowledge and efforts to reduce it. This thesis describes a holistic approach to the problem of resident stress by employing methods of Cognitive Work Analysis to systematically review and organize relevant research literature, observations, interview responses, and survey information according to the area of the work domain where each stressor is likely to occur. Implications for associating literature to a work domain representation include a clearer understanding of how stress is defined in each article associated with the representation, a heightened sense of anticipation for how changes in one section of the residents' work domain might affect other areas of the domain, and use as a visual aid to help in the development of new mitigation methods for stress that consider the constraints provided in the resident's work domain.

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Introduction

Training of Medical Doctors

Premise 1: *It is difficult to create competent doctors.* To become a competent physician, an individual must endure a substantial amount of schooling and years of dedication to the field of medicine. The first phase in becoming a medical doctor is to obtain a bachelor's degree from an accredited college or university and to pass the infamous Medical College Admissions Test (MCAT). This phase helps select candidates who have a strong understanding of mathematics and science to carry-on with more in-depth development of math and science as it is applied to medical concepts.

After passing the MCAT and being accepted into a collegiate medical program, the second phase of pursuing a medical doctorate is the cultivation of the individual's medical knowledge. Once in medical school, the next 4 years generally involve observations and working alongside practicing physicians and residents, along with significant amounts of assignments and readings from medical journals to create a solid foundation of medical knowledge. Once a medical degree has been obtained, the individual must then pursue and complete a residency program.

Residency generally involves 3 to 5 years of continuing to develop medical knowledge while learning to apply this knowledge by practicing on patients. Usually the development a skill begins with a safe environment to start applying one's skills; however, the majority of practice for resident physicians generally takes place in an environment replete with error opportunities, complexity, and critical outcomes. This type of "wicked" learning environment often results in excessive stress on resident physicians.

Upon learning to apply medical knowledge and after sufficient practice during the years in residency, the resident can then take the United States Medical Licensing examination. After passing this exam, the resident is allowed to practice medical care in the United States of America. However, some specialties

require further training in sub-speciality or fellowship programs to be considered fit for practice, which can make pursuing a medical doctorate a seemingly endless process.

Stress in Medical Residency

Premise 2: *Residency is an extremely stressful time during the creation of competent doctors.*

Learning and applying knowledge in healthcare is often characterized by practicing work that is highly critical, unforgiving of errors, requires long working hours, and includes frequent time pressure. This is the working environment medical residents must navigate to become fully certified doctors. While some stress is necessary for the development of competent physicians (LeBlanc & Bandeira, 2007), excessive stress encountered during the years of residency is often too much for novice residents to handle.

Negative consequences of excessive stress encountered during residency have been discussed in numerous studies and have been known to create perceptions of reduced patient care (Firth-Cozens & Greenhalgh, 1997; Shanafelt, Bradley, Wipf, & Back, 2002; Shirom, Nirel, & Vinokur, 2006; Van Den Hombergh et al., 2009). Apart from this negative consequence of stress, resident responses to stress often include unfavorable behaviors such as substance abuse, burnout, anxiety, and depression (Cohen & Patten, 2005). A good depiction of distress caused specifically by medical error is described by Wu (2000):

Virtually every practitioner knows the sickening realization of making a bad mistake. You feel singled out and exposed---seized by the instinct to see if anyone has noticed. You agonize about what to do, whether to tell anyone, what to say. Later, the event replays itself over and over in your mind. You question your competence but fear being discovered. You know you should confess, but dread the prospect of potential punishment and of the patient's anger. You may become overly attentive to the patient or family, lamenting the failure to do so earlier and, if you haven't told them, wondering if they know. (Wu, 2000, p. 726).

Wu's (2000) account highlighted physicians' struggle with reduced feelings of competency after an error, the uncertainty of how the consequences of the error would unfold, and the emotional affect

commonly associated with stressful encounters. Medical errors, however, account for only a small portion of literature discussing the sources of stress in healthcare.

Research investigating sources of stress on residents ranges from the seemingly objective and unavoidable aspects of residents' work, such as time pressure (Adler, Werner, & Korach, 1980; Cohen & Patten, 2005) or intense work demands (Thomas, 2004), to subjective sources of stress such as competency (Luthya, Perrier, Perrin, Cedraschi, & Allaz, 2004; Yao & Wright, 2000) or role ambiguity (Moreno, 2003; Revicki, Whitley, & Gallery, 1997; Blatt et al., 2006). One of the more noted sources of resident stress is sleep deprivation (Houry, Shockley, & Markovchick, 2000; Levey, 2001; Buddeberg-Fischer, Klaghofer, Stamm, Siegrist, & Buddeberg, 2008). Many studies have been devoted to showing that residents who have less sleep have increased levels of stress (Stucky et al. 2009). Interestingly, despite the shift in working hours from 120 hours to 80 hours per week, residents' perceptions of stress on the job did not change (Zare et al., 2005; Hutter, Kellogg, Ferguson, Abbott, & Warshaw, 2006). In fact, Lister, Friedman, Murad, Dow, and Lombard (2010) suggested the duty hour change has reduced the amount of time for residents to fulfill the educational mandates set forth by the Accredited Council for Graduate Medical Education (ACGME), and has resulted in additional stress on the traditional methods of learning in surgical residencies. These findings suggest stress is a complicated concept to target for mitigation, and likely resides in multiple areas of residents' work.

Levey (2001) conducted a large literature review to determine the sources of stress to resident physicians and reported the way the Resident Service Committee of the Association of Program Directors in Internal Medicine has divided the common stressors of residency programs into separate categories: situational stressors, personal stressors, and professional stressors. Situational stressors are sources of stress that include working inordinate hours, sleep deprivation, excessive workload, overbearing responsibilities, inadequate support from other health professionals, and working with difficult patients. These sources of stress are likely experienced by every resident and are closely tied to the work residents are required to complete to provide care to patients. The list of personal stressors included sources of

stress similar to family issues, financial troubles, relocation difficulties, isolation, and limited time for relaxation. This set of stressors is more subjective than the situational sources of stress and likely differ greatly between individuals. The final section describes professional stressors and includes sources of stress such as the responsibility for patient care, information overload, the supervision of junior residents, and difficulties in career planning. This category of stressors seems to share the same objective standpoint as situational stressors since most residents are likely to encounter these stressors, but this category also implies that progressing in the residency program itself is a type of stress frequently experienced by residents. The compartmentalization of these stressors helps to gain an understanding of the vast amount of stressors residing within residents' lives. Given the quantity of stress experienced by residents, it is no wonder that Flegel and Palepu (2003) reported fewer residents in residency programs and a decreased interest of residents to devote their lives to medicine.

Apart from the common stressors that have been categorized according to the Resident Service Committee of the Association of Program Directors in Internal Medicine's standards, less common stressors have also been identified as disruptive to resident physicians. One notable source of stress is the high expectations residents are held to perform by; acting as skilled educators, researchers, and administrators while also being accomplished clinicians (Cohen & Patten, 2005). Other less common stressors that are not labeled in the categories above include the difficulty of establishing a good doctor-patient relationship (Buddeberg-Fischer et al., 2008), the organization of residents' work (Ishak et al., 2009), and the experiencing of a gap in medical knowledge from medical school to the residency program (Luthya et al., 2004).

Clearly, a large amount of literature has been dedicated to the identification of stressors effecting resident physicians. However, the variety of stressors within the literature makes forming a comprehensive picture of the problem nearly impossible. Additionally, the literature on stress during medical residency does not provide an agreed upon definition for stress, which can result in additional issues when drawing conclusions from this research.

Stress and Stressors

Premise 3: *Stress is a difficult concept to define.* Staal (2004) provided a thorough literature review that discussed the difficulties of studying stress and mentioned some of the issues with defining stress. In his review, Staal (2004) highlighted a statement by Stokes and Kite (2001) (as cited in Staal, 2004) that explains the confusion of defining stress as likely stemming from stress being viewed as “an agent, circumstance, situation, or variable that disturbs an individual’s normal function or is seen as an effect due to some disruption.” Given this difficulty, Staal (2004) concluded the most putative definition of stress was defined by McGarth (1976) (as cited in Staal, 2004): “Stress is the result of a mismatch between the perceived demand, the perceived ability to cope, and the perceived importance of being able to cope with a demand.” This definition of stress focuses on the individual’s perception of events, and suggests stress is not something that exists objectively in an environment. Given the different associations and believed causes of stress in medical literature, some authors adhere to the idea of stress as a perception (Cohen & Patten, 2005; Lindholm, 2006), while other authors imply stress exists objectively within the work environment (Hillhouse, Adler, & Walters, 2000; Biaggi, Peter, & Ulich, 2003; LeBlanc & Bandeira, 2007.). This discrepancy between authors investigating stress likely adds to the difficulty of providing stress with a definition, and also portrays the erroneous assumptions that are made regarding “stress” in resident stress literature. For the purpose of this research, the preceding definition provided by McGarth (1976 as cited in Stall, 2004) will be used to define stress as a concept, while “stressor” and “source of stress” will be used synonymously to describe the objective or subjective context in which stress is perceived to occur.

Due to the wide variety of areas stress has been identified in medical residency and the different ways stress is viewed within medical resident literature, gaining a holistic understanding of how stress manifests itself to residents seems a nearly impossible task. However, a common factor that that can be used to unite the information discussing resident stress is the work domain. Cognitive work analysis is an approach that provides tools and techniques for the analysis of socio-technical work systems that often result in representations that communicate complex information about systemic or cognitive processes.

Cognitive Work Analysis

Premise 4: *Cognitive work analysis provides techniques to organize and analyze complex systems.*

Cognitive work analysis is a framework that systematically analyzes the work people do, the tasks they perform, the decisions they make, and the ways they seek and use information to perform their work for the ultimate purpose of establishing human-system integration requirements for a work domain (Lintern, 2009). The main goal of cognitive work analysis is to support the development of systems that allow workers to adapt to novel situations and change throughout the entire system (Vicente, 2002). To identify areas of work that might hinder the adaptability of a system, cognitive work analysis provides techniques and analyses that create representations of how work and information are dispersed throughout the system, which aids in the identification of limits to work, and restrictions to adaptability.

Naikar (2006) described the applicable power of supporting and adjusting constraints within the work environment by applying the cognitive work analysis framework to different industrial projects, including the development of training systems, the evaluation of design proposals, and to analyze human error. The applicability of cognitive work analysis has even extended into various domains of healthcare.

Hajdukiewicz, Doyle, Milgram, Vicente, and Burns (1998) applied one stage of cognitive work analysis, known as the work domain analysis, to build representations of anesthesiologists work domain, which provided useful insights to training procedures and interface design. In a later study, also performed by Hajdukiewicz et al. (2001) the research team performed a work domain analysis investigating surgeons' work, and developed an abstraction hierarchy to integrate the surgeon's work domain (i.e., the human body) to biological knowledge. The occurrence of a critical event in the operating room revealed the framework created by Hajdukiewicz et al. (2001) supported medical problem solving when faced with a rare event. These examples provide evidence of the applicable power of cognitive work analysis and the work domain analysis in incredibly complex environments such as modern healthcare.

As previously mentioned, the work domain analysis is a technique within cognitive work analysis that creates a representation of a socio-technical system's work domain, known as the abstraction-

decomposition space. The abstraction-decomposition space identifies the important, activity-independent structure of the work domain, to aid researchers in understanding the necessary values and priorities, work functions, technical functions, and physical resources to fulfill the domain purpose of the complex socio-technical system (Lintern, 2011). The purpose of an abstraction-decomposition space is to identify aspects of a work domain that either support the achievement of the domain purpose or constrain against it.

The typical abstraction-decomposition space representation portrays the domain purpose as the final element composed of more detailed levels that follow in a hierarchical fashion. The domain purpose is listed at the top of the representation, followed by the domain values and priorities, the work function to obtain the values and priorities, the technical functions necessary to fulfill the work functions, and ending in the physical resources required to fulfill the technical functions (either people for socio-technical systems, or technological components for technical systems). Within each of the aforementioned levels of the abstraction-decomposition space, functions of the work domain are placed as nodes. Links between nodes at different levels represent means-ends relationships between the linked nodes (Lintern, 2011)

Purpose of the Research

The difficulty of creating competent doctors has resulted in substantial amounts of stress to resident physicians in multiple aspects of their work. In addition, the ambiguous use of the term stress also makes understanding stress as it has been studied in residency programs nearly impossible. Using tools and techniques familiar to cognitive work analysis, specifically the work domain analysis, can provide a context-independent structure of the residents' work domain known as the abstraction-decomposition space. This representation should also be a useful tool to investigate complex concepts, such as stress, that permeate all levels of the work domain..

Hypothesis

By exploring stress associations to nodes and connections of an abstraction-decomposition space representing the medical residents' work domain with observations, interviews, and surveys in a large

general hospital should provide a look into the types of stress that are prevalent within the residency program and provide insight for mitigating resident stress. Additionally, associating results from a literature review on resident stress with elements of the abstraction-decomposition space describing the residents' work domain should provide a deeper understanding of how stress manifests itself within residents' work and provide a better understanding of how the term stress is characterized within residency programs as well as within the field of medicine in general.

Method

Development of the Abstraction-Decomposition Space

To develop the abstraction-decomposition space representing the medical residents' work domain, information was collected from texts including Accredited Council for Graduate Medical Education competency documents (ACGME, 2011), residency program requirements (ACGME, 2007), and the residency program manual (Rochester General Hospital, 2011). After reviewing this literature and creating a basic outline detailing the components relevant to the resident's work domain, an interview with a residency program director at Rochester General Hospital (RGH) was conducted to gain additional understanding of how the residents' work domain is structured. The interview elicited information about the domain purpose, values, work functions, technical functions, and physical resources that constitute the residents' work space (See Appendix A).

Literature Review

Relevant articles were collected from numerous peer reviewed journals including the *Journal of Graduate Medical Education*, the *Annals of Emergency Medicine*, *Academic Medicine*, and the *Journal of the American Medical Association*. The tools used to conduct this literature search included the Rochester Institute of Technology's (RIT) Wallace Library search engine, the ACGME journal archives, and the Google Scholar search engine. Keywords used to retrieve the articles from these databases included: resident, physician, stress, perceptions of stress, residency, medical resident, work stress, and burnout.

Node and Connection Literature Associations

After completing the representation of the resident physicians' work domain, medical literature discussing resident stress was associated with the representation according to which node or connection of the abstraction-decomposition space the results of the resident stress article most identified with. A brief description of the article's results followed by a citation were then listed next to, and connected to the corresponding node or connection to show this association. If there were multiple results within one

article that covered varying parts of the work domain, each result was listed and connected to the abstraction-decomposition space node according to the best matched connection, but the same citation was used for each associated result.

In addition to the development of the abstraction-decomposition space representation and the node/connection associations within this representation, considerable effort was expended to gain an understanding of stress within the resident physicians' work domain. For this study, observations and interviews were used to gain a clearer understanding of the sources of stress prevalent in the hospital. After conducting this data collection, results from the abstraction-decomposition space literature association, observations, and interviews were utilized in the development of a survey aimed at identifying where stress exists in the residents' work domain and to verify the literature node/connection associations made in the abstraction-decomposition space representation.

Participants

Participants for observations, interviews, and surveys consisted of internal medicine residents practicing at Rochester General Hospital. Residents taking part in this study included 1st year, 2nd year, and 3rd year residents in the program, along with chief residents who have recently graduated the residency program at RGH, but were honored by the hospital to stay and help coordinate and advise residents currently in the residency. This study recruited participants by coordinating with supervisory staff at RGH and accepting volunteered participation from residents. Once agreeing to take part in this study, participants were briefed on the data collection methods (observation, interview, and survey). They signed a consent form stating they understood the methods and consented to participate in this study.

Observations

Observations were conducted in the medical intensive care unit (MICU), which is a unit that consists of 16 beds where critical care patients are brought, assessed, and attended to. Additional observations were taken in the medical assessment team intensive care unit (MAT ICU) which is an 8 bed unit that requires residents to closely monitor patients who are too ill for regular hospital beds, but not ill enough

to be sent to the MICU. The primary purpose for observing residents work in these areas of the hospital was to become familiarized with the field of internal medicine and to gain a first-hand look at resident stress. A secondary reason for conducting observations was focused on evaluating the aspects of residents' work that appeared to be causing significant stress to them. To conduct observations, a member of the research team would follow a resident throughout his or her work day and take notes on any task or situation that appeared to stress the resident.

Interviews

Interviews were conducted with residents to gain a deeper understanding of the different sources of stress they encountered while working. The semi-structured interview technique employed by this project closely mimicked the Critical Decision Method (Crandall, Klein, & Hoffman, 2006). Interview questions instructed resident physicians to describe a stressful situation while the researcher recorded a timeline of different critical moments in the event. After documenting the critical points in the stressful situation, the researcher then asked questions to gain a deeper understanding of why the critical moments in the stressful situation were considered stressful (see Appendix B). Resident responses were recorded using an electronic voice recorder, then manually transcribed for detailed analysis.

Survey

After completing the abstraction-decomposition space representation, associating results from resident stress literature with the nodes and connections within the representation, and analyzing observations and resident interview responses, a survey was developed. This survey was created to investigate where stress was occurring within residents' work, and to verify the stress associations within the abstraction-decomposition space representing the residents' work domain. To administer the survey, the Rochester Institute of Technology Clipboard online survey tool was used. The Clipboard tool, developed by the Wallace Center at RIT, is an online survey system that is used to create and administer surveys on and outside of the RIT campus. For this study, a link was provided to the survey via email with a paragraph that described the purpose of this study to the residents and informed them that by participating in the survey they consented to take part in the study. Questions on the survey included

basic demographic inquiries, Likert scale questions that asked residents if they “Strongly Disagreed”, “Disagreed”, were “Neutral”, “Agreed”, or “Strongly Agreed” with statements about stress in different areas of their work, and a portion that required residents to rank which group of employees was most stressful to work with. Statements used for the Likert scale portion of the survey were derived from the abstraction-decomposition space representation and targeted resident physicians’ experiences with stress in different aspects of their work domain, while the ranking portion of the survey was derived from relevant identities in the physical resources portion of the abstraction-decomposition space. (Appendix C)

Results

A Critical Review on Defining Resident Stress

To show the difficulty of defining stress in medical resident literature and to gain a better understanding of the different types of stress effecting medical residents, I reviewed 50 medical articles that range in date from the early 1989 to 2012 and investigate resident stress.

In 1989 Kirsling and Kochar published a literature review on contributing factors to resident suicide. The authors discussed how contributors and manifestations of stress could play a part in physician suicide rates. Multiple contributors to resident stress included role ambiguity, number of work hours, fatigue, breakdowns in communication, and personality factors along with various manifestations of stress, which include cognitive impairment, depression, chronic anger, and substance abuse. The majority of the manifestations of stress are grouped into one disorder titled “house-officer stress syndrome”, which shares similarities to current definitions of burnout. Although this article provided a good review of contributors and manifestations of stress in literature prior to 1989, it lacked a formal definition for the term stress.

The lack of a definition for the term stress is a common problem throughout the majority of resident stress literature in the 1990’s (Wartman, O’Sullivan, & Cyr, 1990; Doan-Wiggins, Zun, Cooper, Meyers, & Chen, 1995; Lum, Goldberg, Mallon, Lew, & Margulies, 1995; Revicki et al., 1997; Daughtery et al., 1998.). The majority of these studies identified factors and situations that contribute to stress within residency programs. Given the lack of a shared definition for the term stress in this decade of literature, it is difficult to know if the aforementioned authors have a shared understanding of the concept of stress, or if an unidentified definition for stress was assumed throughout these articles. Regardless, it is important to define stress as it pertains to one’s research goals as it helps clarify and validate the study’s findings. Aside from the possible assumptions made about how stress is defined as a concept, another issue was found within this section of literature involving term ambiguity.

In a study aimed at analyzing correlations between “stress”, “psychological strain”, and “behavioral reactions”, Jex et al. (1991) came across term ambiguity regarding the outcome variable of his study when compared to other studies. In his article, the term ‘psychological strain’ was used to describe psychological or emotional reactions specific to various stimuli. However, Jex et al. (1991) mentioned two different studies that also investigated the mediating variables of stress, but similar outcome variables were defined by different terms. In the first study, authored by Motowidlo et al. (1986) (as cited in Jex et al., 1991) the authors termed the outcome variable to be ‘stress’; and in the second study Thompson (1989) (as cited in Jex et al., 1991), labeled the outcome variable as ‘felt role stress’. Jex et al. (1991) acknowledged these terms are likely very similar conceptually and operationally, but he also calls for greater clarification in order to produce more accurate models of stress processes.

Another thought raised in the 1990’s literature is the idea that stress is tightly connected to the person’s line of work. Gerrity and Earp (1992) conducted a study to investigate stress through measures of uncertainty via interviews and surveys. However, one physician’s response to a question asking about the amount of uncertainty associated with other specialties in the hospital (general internal medicine, psychiatry, pediatrics, etc.) shows an interesting view of stress. Although all physicians are familiar with the uncertainty associated with their own specialty, one physician commented: “I don’t feel that physicians in different specialties understand what someone in another specialty really does and the kind of stresses he or she deals with.” (Gerrity and Earp, 1992, pp. 1039) This comment suggests the term ‘stress’, as it is used in the field of medicine, could be closely related to the work domain where the stress is encountered.

Overall stress has been poorly defined in the 1990’s medical residency literature. Besides the lack of a definition for stress in the articles previous listed, these articles provide helpful insights into the issues brought about by neglecting a definition or having an ambiguous definition of stress, and introduced the notion of stress being defined according to the work domain in which it is perceived.

The majority of literature obtained for the current study fell between the years 2000 and 2009. Similar to the literature in the 1990's, the majority of authors in this time frame neglect to provide an explicit definition for what the term stress is or implies. To add to the difficulty in providing a united definition for stress, some authors use various terms such as “distress”, “stressor”, “psychological stress”, and “occupational stress” interchangeably with the term stress (Houry et al., 2000; Luthya et al., 2004), where other authors draw firm distinctions between seemingly similar terms or concepts such as psychological strain and stress (Jex et al., 1991; Biaggi et al., 2003). By providing definitions for the terms stressors and strains, Biaggi, Peter, and Ulich (2003) allowed readers to gain a better understanding of how these two similar concepts interact with one another, and provided a better view on the similarities and differences between these two concepts. Apart from Biaggi et al., (2003) another author (Lindholm, 2006) offered a definition for stress related concepts in the timeframe between the years 2000 and 2010.

Lindholm (2006) provided a study that investigated different working conditions such as support systems, salary, and sick leave, and how these working conditions were associated with work stress in chief nurses and physicians. Like Biaggi et al., (2003), Lindholm (2006) offered an explicit definition to the term ‘work stress’ that was derived from previous authors (Arnold, Cooper, and Robertson, 1998 as cited in Lindholm, 2006). Arnold, Cooper, and Robertson (1998) (as cited in Lindholm, 2006) define work stress as: ‘any force that pushes a psychological or physical factor beyond its range of ability, producing strain within the individual.’ As with Biaggi et al, (2003), providing this definition promotes a shared understanding of what work stress meant in Lindholm’s (2006) article, which clarifies the associations of the study, and lends a better foundation to make claims about this study’s results. Regardless of whether or not the definition of “work stress” Lindholm (2006) chose to use was the most current or popular definition, providing any definition at all helped to validate the study’s findings.

Another popular construct that crops up in stress literature between 2000 and 2010, is burnout syndrome. Burnout syndrome, as characterized by the Maslach Burnout Inventory is primarily composed of three domains: emotional exhaustion, depersonalization, and lowered feelings of accomplishment or

self-achievement (De Oliveira et al., 2011). This syndrome is commonly described as being closely related to stress, but there is one distinction to be made. Burnout is generally seen as an outcome that is triggered by chronic job stressors (Hillhouse et al, 2000), suggesting that burnout in and of itself is not considered a source of stress. However, the previous assumption remains open to debate, given the lack of a definition for stress provided by Hillhouse, Adler, and Walters, (2000).

A small amount of literature was obtained for the years following 2009. As with the previous years mentioned in this review, there is a general lack of definition for the term stress in the most current resident medical literature (Baldwin, Daugherty, & Ryan, 2010; Lister, Friedman, Murad, Dow, & Lombard, 2010; De Oliveira, Almeida, Ahmad, Fitzgerald, & McCarthy, 2011). Due to the deficiency in literature regarding resident stress for years postdating 2009, it is almost certain the trend of neglecting a definition for stress will prevail in future literature. However, given the lack of definitions for stress in the literature previous to this decade, it is understandable why the lack of a definition for stress could become an issue in current medical resident literature.

Literature Review on Resident Stress

The literature review describing the difficulties of obtaining a definition for stress in medical resident literature also provided sources of stress to be associated with the abstraction-decomposition space describing the residents' work domain. Specifically, the 50 research articles reviewed discussed 74 different sources of stress and burnout in medical residency. Some sources of stress were similar to each other (example, "Time pressure" listed by Cohen and Patten, 2005 and "Time demands" listed by Ishak et al., 2009) but investigated by different researchers or methods, so although similar, such sources of stress were considered separate. Sources of stress from resident stress articles, as well as the articles themselves, were then associated to relevant nodes and connections within the abstraction-decomposition space representation of the residents' work.

Observations

Approximately 20 hours of observations were spent witnessing residents work at the hospital. The majority of these observations took place shadowing 3rd year and chief residents in the MICU and the MAT ICU and recorded large amounts of notes on potential sources of stress for residents in each environment. These notes were further analyzed and associations were drawn between apparent stressors witnessed at the hospital and the abstraction-decomposition space developed to represent the residents' work domain.

Interviews

A total of six interviews were conducted with residents from varying years of residency including one 1st year resident, one 2nd year resident, one 3rd year resident, and three chief residents. After transcribing the interview responses, relevant interview responses were associated to the nodes and connections of the abstraction-decomposition space describing the residents' work domain.

Work Domain Analysis

The abstraction-decomposition space produced from the interview with the residency program director and the use of relevant training documentation is given in Figure 1. This representation was primarily used to create associations between relevant literature results from resident stress literature, observations of residents' work that seemed to produce stress, resident interview responses that identified significant stressors residents have encountered, and aid in the development of the survey to investigate where stress has been occurring in the resident physicians' work domain. After creating these associations, the counts of research articles, distinct stressors found in the literature, observed stressors, and resident interview responses are shown in Figure 2, by the nodes and connections they were associated with in the abstraction-decomposition space representing the residents' work domain (Figure 1).

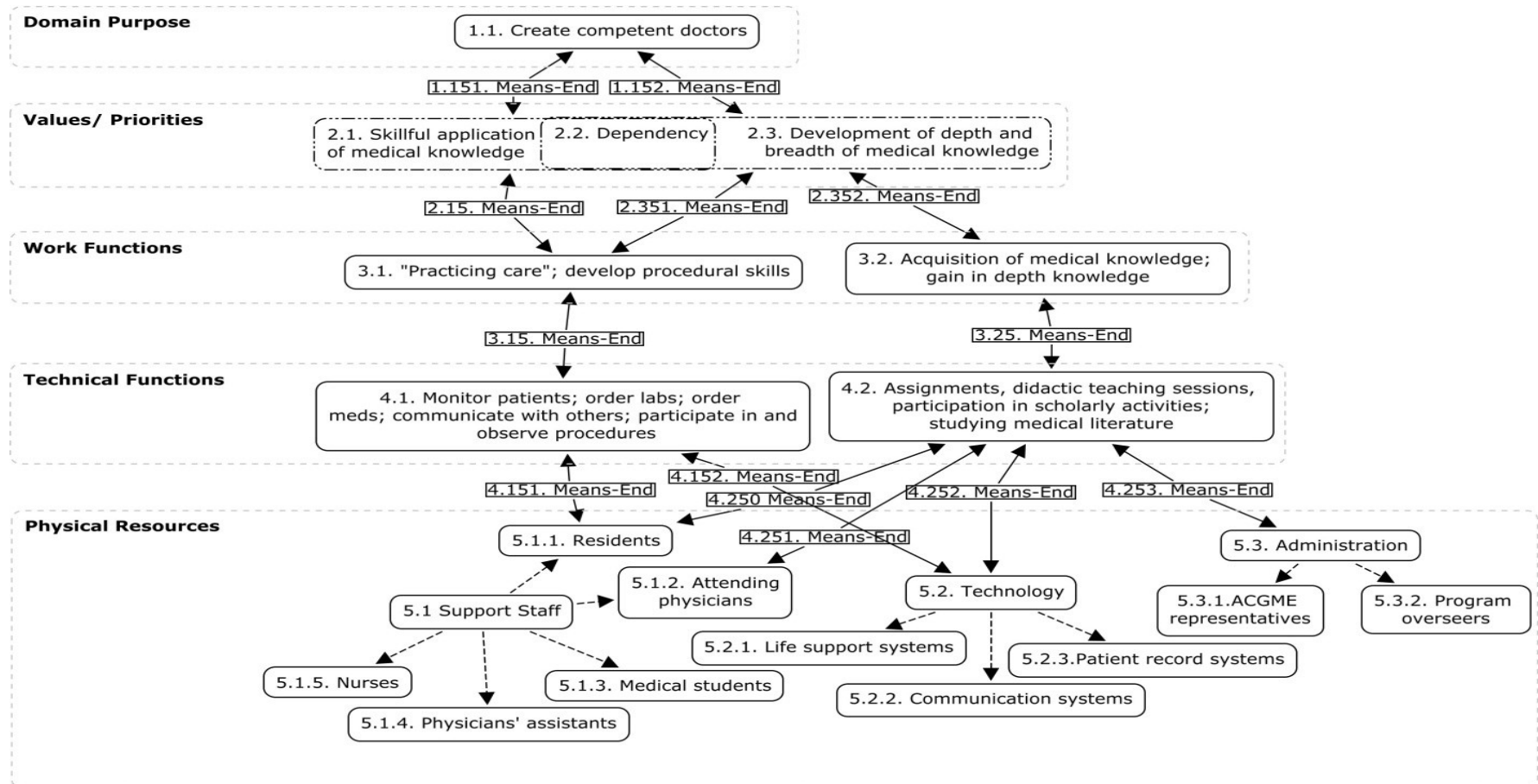


Figure 1. The abstraction-decomposition space describing the residents' work domain created from an interview with the residency program director and relevant program training documents. The nodes and connections were numbered to facilitate easy association of stressors identified in the literature with them, and they are also referred to by number in the text.

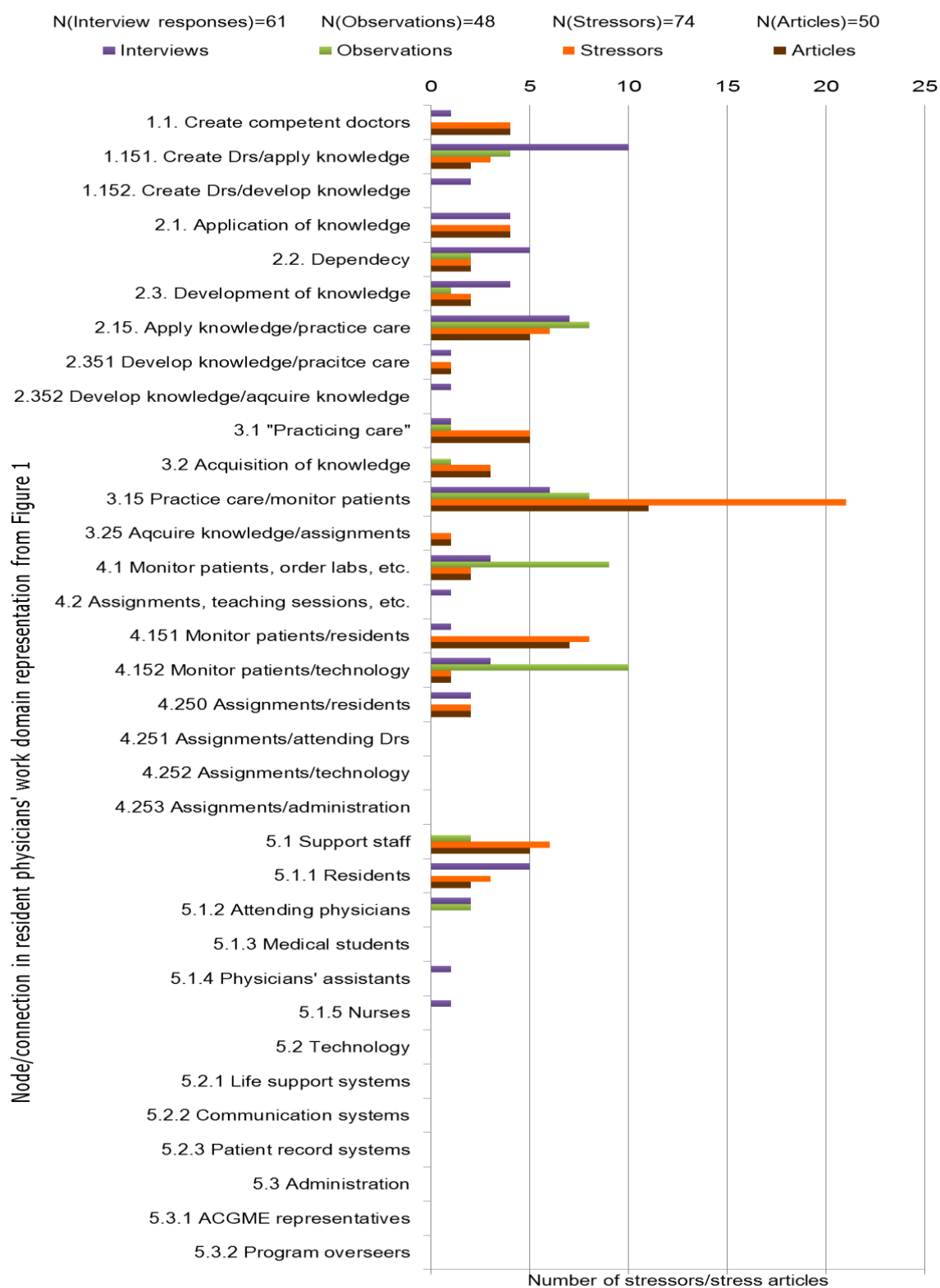


Figure 2. This graph portrays the counts of research articles, distinct stressors found in the literature, observational data, and interview responses shown as a value of the stress associations made to the abstraction-decomposition space (Figure 1).

Abstraction-Decomposition Space: Node and Connection Associations

Each source of stress from the literature, noteworthy observation, interview response, and question on the survey was associated to a node or connection found within the abstraction-decomposition space representing the resident physicians' work domain (Figure 1). To aid in the comprehension of the literature, observation, and interview associations to the representation, descriptions are provided in each paragraph below that describe the level of the work domain where the node/connection association was made, the number of each node or connection, the stress associated with this node or connection from literature, observations, or interviews, and a brief explanation of the association process for each documented or observed stressor association.

Domain purpose. The domain purpose describes the reason why a specific domain exists (Lintern, 2011). During the interview with the program director to aid in the construction of the abstraction-decomposition space, the director repeatedly mentioned creating competent doctors was the reason for having residency programs at hospitals. Given this information, "create competent doctors" was determined to be the domain purpose.

Create competent doctors (1.1). To associate resident stress with the domain purpose, results from our methods of data collection needed to suggest stress as an outcome or contributor to residents' feelings of being recognized as a competent physician, such as role ambiguity; or suggest stress as a product of uncertainty in future endeavors for residents.

Literature associations. Findings from the resident stress literature review that align with the create competent doctors node include stress from future career prospects (Biaggi et al., 2004) and residents' struggling with their new identity as physicians (Moreno, 2003; Blatt, Christianson, Sutcliffe, & Rosenthal, 2006; Revicki et al., 1997).

Observations. Only one observation was noted to be relevant to this node of the resident's abstraction-decomposition space. While conducting observations in the MAT ICU, one resident

mentioned his worry about getting into a fellowship program. Besides this comment, no other behaviors or comments were noted to be relevant to this node.

Interview responses. During interviews with residents, one resident mentioned a stressful experience with the nurses in the ICU that mildly pertains to the domain purpose. The resident commented:

“There were also issues about my autonomy for patient care. They (the nurses in the ICU) felt that, as an intern, I was given a little too much independence and liberalism in the way I manage my patients. I felt I was expressing myself as a new doctor. In the end it works itself out.”

Although this statement also suggests stress as an outcome of collaborating with the nursing staff in the medical ICU, the nurses believing the resident was given too much independence as an intern, might also create a source of role ambiguity for the resident.

Create competent doctors and the skillful application of knowledge (1.151). Stress from the data we collected was associated with this connection between the “creating competent doctors” node in the domain purpose and the “skillful application of medical knowledge” node in the values/priorities section, if the results suggested stress as an outcome of feeling responsible for a patient’s health. Responsibility is an important aspect of becoming a competent physician, but responsibility can also provide a large amount of stress to physicians; especially if the doctor does not perceive his or her skills as adequate for the responsibility of patient care.

Literature associations. Sources of stress from the literature review found relevant to this node include the responsibility for patient care (Levey, 2001; and Luthya et al., 2004) and overbearing responsibilities (Levey, 2001).

Observations. Observations that relate to the connection between the “create competent doctors” node and the “skillful application of knowledge” node included observations of residents dealing with large amounts of responsibility. For example, in the MICU, one senior resident is generally responsible for up to 20 patients at any given moment. Additionally, Second year residents are generally left

responsible to manage the MAT ICU, including judgments about when patients should be sent somewhere besides the MAT ICU. It is also important to note the observed relationship between a resident's experience and responsibility. As a resident physician becomes more experienced, they are given more responsibility towards patient care. This finding is also noted in the interview responses below.

Interview responses. Multiple interview responses were collected from residents that suggest responsibility for patients is a large source of stress within the residents' work domain. For example, one resident stated:

"The stress comes with the responsibility of taking care of a patient, but with that responsibility, comes a great reward when you actually diagnose somebody"

This statement portrays the perception by residents of stress coming from the responsibility of caring for patients. Similar statements were made by residents feeling stressed about being the only person in charge of several beds in the MAT ICU, the fear of suffering consequences due to poor practice of patient care, and the responsibility to provide care to every aspect of a patient's condition.

Create competent doctors and the development of knowledge (1.152). Similar to the connection 1.151, stressors were associated with this node if the literature, observation of residents, or resident responses in interviews indicated the responsibility of developing a broad and deep understanding of medical concepts to act as a source of stress to residents or to interfere with their perception as competent physicians.

Literature associations. No literature was found to indicate the responsibility of developing a deep understanding of medical concepts as a source of stress to residents.

Observations. No observations were found to be relevant to this connection.

Interview responses. One resident made statements that indicated stress as a result of uncertainty associated with his responsibility to develop a deep and broad understanding of medical concepts.

"As for the stress, you start questioning; am I working hard enough? Am I actively learning? Am I reading enough journals? Will I ever be at a point where I consider myself equal among these people?"

The same resident also noted the intimidation he encountered while working with residents superior to him or attending physicians who have a "repertoire of knowledge so much greater than yours" (meaning his). These statements are the only indication of stress stemming from the responsibility to develop a broad and deep understanding of medical concepts in lieu of becoming a competent physician.

Values and priorities. The values and priorities are the guiding concerns of the work domain used to fulfill the domain purpose (Lintern, 2011). Throughout the residency training manuals and during the interview with the program director, education and providing care to patients were identified as values to be maintained, but practicing one of these values is usually dependent on practicing the other value. This is the renowned service/education conflict identified by the residency training literature, the program director interviewed for this study, and in the literature by Wartman, O'Sullivan, and Cyr (1990). However, because labeling these inter-dependent nodes "education" and "providing care to patients" does not clearly communicate how the domain purpose is fulfilled by upholding these values; they were renamed to more clearly portray how they interact with the domain purpose. The two interdependent nodes composing the values and priorities of the residents work domain have been labeled the "Skillful application of medical knowledge" and the "Development of depth and breadth of medical knowledge".

Application of medical knowledge (2.1). The skillful application of knowledge picked up during the residents' years at medical school and in the residency program determines their ability to provide quality care to patients and is considered a guiding concern to becoming a competent physician. To associate stress from our data collection, resident literature, observations, and interview responses needed to indicate a perceived violation of the skillful application of medical knowledge.

Literature associations. Stress results from the literature review that suggested residents encountering stress from feeling responsible for the death or suffering of patients (Jex et al., 1991), the

number of patient deaths (Baldwin, Dodd, & Wrate, 1997; Cohen & Patten, 2005), or a high emotional investment towards patients (Luthya et al., 2004) were all considered as perceived failures to uphold the value of skillfully applying medical knowledge, and associated with this node.

Observations. No observations were found to be relevant to this node.

Interview responses. During interviews with resident physicians, residents made statements that suggested stress as a perceived violation of the value to skillfully apply medical knowledge. Comments include statements about residents feeling they could have done more to prevent a patient's death, anxiety stemming from the pressure and uncertainty of being able to save a patient's life, and resident expressions of the most stressful days being emotionally laden.

Dependency of developing knowledge and the application of knowledge (2.2). In order to associate resident stress with the dependency between the “skillful application of medical knowledge” and the “development of depth and breadth of medical knowledge”, results needed to portray stress as a result of the dependency to practice knowledge while developing knowledge in the residents' domain.

Literature associations. Literature supports the existence of this paradigm, and highlights the difficulties of identifying which activities constitute the practice of skill, and which constitute the development of a deep understanding of medical concepts (Wartman et al., 1990). However, only one stress article was found to be directly associated with this node. LeBlanc and Bandeira (2007) described the importance of acute stressors, such as medical emergencies and examinations, as an important and inherent part of medical practice. This statement portrays stress as a source of the dependency of practicing skills to develop an applied medical knowledge.

Observations. Few observations were made that suggested this dependency as a source of stress to residents, but multiple observations were made of senior residents quizzing first year residents about a patients state and why, or how ,they got there. Also, observations of attending physicians helping residents interpret patient data were made and interpreted as relevant to this node.

Interview responses. Resident interview responses to questions inquiring about stressful aspects of their work indicated stress as a source of skillfully applying knowledge while developing a deep understanding of medical knowledge. For example, resident responses that were associated with this node included statements of stress as a result of “not knowing what to do with a patient” and “learning how to do something, while trying to prove you can do it”. Additionally, one resident mentioned the importance of learning from practice, commenting:

"The interns have learned the signs before collapse and things like that. But, similar to a picture being worth a thousand words, when one patient collapses on you, you never forget it. Until you see that patient, you question ‘is this what the book was talking about?’"

A different resident highlighted difficulty with his peers perceptions of him actively learning, stating:

"As an intern it's perfectly ok to say I don't know, that's expected. At the same time, you want to show everyone that you are actively learning and capable of making decisions. And that can be stressful. Making decisions to not only help the patient, but to prove to your colleagues you are capable and competent; so there is some pressure on that."

The preceding remarks suggest the importance of practicing skills while developing knowledge in the medical domain and the stressful nature of applying knowledge while practicing the application of skills to achieve competency among fellow physicians.

Development of medical knowledge (2.3). The development of a deep and broad understanding of medical concepts is the backbone of residency education towards creating competent physicians. To associate stress with this node, statements, observations or responses needed to indicate stress as the product of something impeding the fulfillment of developing a deep and broad understanding of medical concepts.

Literature associations. To associate literature results with this node, research has suggested the learning environment in hospitals is a large contributor to stress experienced by residents (Levey, 2001; Tyssen, Vaglum, Grønvold, & Ekeberg, 2005).

Observations. Only one observation was noted to be associated with this node. During observations in the MAT ICU, one resident mentioned the importance of knowledge gained in medical school and developing strong research skills to find out as much as possible about the patient he will be working with, to reduce the amount of stress experienced when working with the patient.

Interview Responses. Sources of impediment to residents' development of medical knowledge highlighted through interview responses included the lack of a figure to look up to, leaving one resident to feel he was left to learn things on his own. Additionally, residents also made remarks about the subtle ways in which they are taught within the residency program (see comment below).

"I guess in our profession, learning comes in very subtle ways. You see one or two things or you read a case report here and there. And they kind of think you are trained. Then that is how you hone your skills; basically."

Application of knowledge and practicing care (2.15). To associate resident stress results with the means-end connection between the "skillful application of medical knowledge" node in the values and priorities section, and the "practicing care" node in the work functions section, resident stress literature needed to suggest stress as an outcome of something hindering the ability to practice medical skills.

Literature associations. Resident stress literature results that suggested stress as an outcome of difficulty escaping job demands (Buddeberg-Fischer et al., 2008), difficult job situations (Ishak et al., 2009), the complexity in dealing with patient issues (Stucky et al., 2009), difficulty establishing the doctor-patient relationship (Buddeberg-Fischer et al., 2008), working with difficult patients (Levey, 2001), and the uncertainty of treatment outcomes (Revicki et al. 1997), can presumably make the process of developing skills laborious and stressful for residents.

Observations. Multiple observations made in the medical and MAT ICU were suggestive of stress as an outcome to the hindrance of applying medical knowledge. For example, residents encountered a large variety of difficult job situations including the need to keep track of multiple issues for multiple patients, discussing the status of a very ill patient to members of the patient's family, working through multiple distractions and interruptions, and working with a lack of patient history or information about what brought the patient to the MICU.

Interview responses. Multiple responses during interviews with resident physicians suggested the ability to apply medical skills and knowledge was being constrained. For example, residents indicated the difficulty imposed by some conditions or diseases as a source of stress:

"... this guy had basically been seizing right in front of my eyes for 8 or 9 hours now and I never caught it."

In addition, multiple residents mentioned specific job situations as stressful, including do not resuscitate/do not intubate patients, a very anxious family to deal with while working on the patient, and dealing with patients who are crashing.

Development of knowledge and practicing care (2.351). Resident stress was associated with the connection between the "development of depth and breadth of medical knowledge" node and the "practicing care/developing procedural skills" node if the author or data indicated difficulty in practicing the application and acquisition of medical knowledge.

Literature associations. The only association to this node drawn from the literature was found in an article published by Cohen and Patten (2005). These authors mentioned the importance of residents to learn to become "jugglers of the mind" who are able to balance large amounts of complex biological, psychological, and social interactions during training. This statement portrays the difficulty imposed on residents to sort and apply a wide assortment of knowledge spanning various fields.

Observations. No observations were found to be relevant to this connection.

Interview responses. One resident's response in an interview implied stress as an outcome of balancing knowledge for what is going on with the patient while providing care for the patient.

"These are patients that you don't know from your practice and your clinics, and you are trying to figure out what is going on with the patient from a to z."

Development of medical knowledge and the acquisition of medical knowledge (2.352). To associate stress literature with this node, stress needed to be identified as the result of something hindering residents' ability to develop a deep understanding of medical concepts.

Literature associations. One literature association was found to be relevant to this connection. Levey (2001) mentioned residents' difficulty in adapting to an ever changing healthcare environment. If the information residents are learning is in a constant state of change, this presumably will have an impact on the development of a solid understanding of medical concepts.

Observations. No observations were found to be relevant to this connection.

Interview Responses. One resident described the stress of learning different causes and diagnoses for a disease that were unfamiliar to him during medical school in his home country.

"It was a case of diarrhea; but the causes of diarrhea back home are different than causes of diarrhea in the states. The way I would have diagnosed the disease back home is not even used here, and I would have looked like a complete idiot if I approached it the way I was taught in my home country. It was a very simple case, but I was not familiar with the system here, so I looked foolish while trying to figure it out."

Work functions. The work function section of the abstraction-decomposition space describes the essential responsibility of an activity that is independent of any physical devices being used (Lintern, 2011). Generally put, this section describes why a specific task is being carried out. To determine what the work functions of the residency program are, information was obtained during the interview with the program director that indicated the importance of tasks being carried out in order to learn how to practice

care. For our representation, we separated this comment into two pathways: one pathway that originates in the “application of medical knowledge” node in the values and priorities section that describes the application of skills in the medical environment, and a second pathway that originates from the “development of medical knowledge” node in the values and priorities section that describes the acquisition of medical knowledge.

Practicing care (3.1). To associate stress with the development of skills node within the work functions section, results needed to identify stress as the product of the misapplication of a skill or the underdevelopment of a skill.

Literature associations. Literature associations to the “practicing care” node included findings indicating self-perceived errors are common among internal medicine residents and are associated with substantial subsequent personal distress (West et al., 2006), difficulty reporting or discussing mistakes (Sexton, Thomas, & Helmreich, 2000), the “sickening realization” physicians experience after making a bad mistake (Wu, 2000), and how skill-based errors are the most common unsafe acts in the operating room (ElBardissi, Wiegmann, Dearani, Daly, & Sundt, 2007).

Observations. Only one mistake was observed throughout the 20 hours of observation in the MICU and MAT ICU. One resident physician misapplied a catheter and was required to redo the entire procedure under the close supervision of an attending physician and chief resident.

Interview responses. Surprisingly, only one resident discussed committing a medical error and implied feeling stressed about it afterwards:

“I accidentally pulled a dialysis catheter when I shouldn't have. It wasn't stressful because of the people around me, per se, but because I realized it wasn't a mistake I didn't know about. The moment I made the mistake, I knew it.”

“Practicing care” and monitoring patients (3.15). Stress was associated with the connection between the practicing care node located in the work functions section and the node beginning with

"monitoring patients" in the technical functions section, if results indicated stress as an outcome of performing multiple tasks in the effort to practice care.

Literature associations. A large amount of literature was found to be associated with this connection. Results that were associated to this segment of the residents work domain included time demands (Ishak et al., 2009; Buddeburg-Fischer et al., 2008, Cohen & Patten, 2005; Adler et al., 1980), sleep deprivation (Stucky et al., 2009; Buddeberg-Fischer et al., 2008; Cohen & Patten, 2005; Levey, 2001; Jex et al., 1991), workload (Luthya et al., 2004; Cohen & Patten, 2005; Levey, 2001; Biaggi et al., 2004), intense work demands (Thomas, 2004), the lack of time away from the job (Biaggi et al., 2004), working excessive hours (Buddeberg-Fischer et al., 2008; Jex et al., 1991), the frequency of calls (Cohen et al., 2005), total patient load (Stucky et al., 2009), and physical or mental deterioration (ElBardissi et al., 2007). All are well documented stressors in resident physician literature. However, it is important to note these sources of stress are not present within the tasks themselves, but are more closely related to the demands of residents work to provide patients with care; those demands being timeliness, thoroughness, and intent to provide care.

Observations. Given the location of where the observations were made for this study (the medical and MAT ICU), a large amount of observed stress was found to be associated with this connection in the residents' work domain. Most notably, residents seemed to encounter stress when dealing with large amounts of patient information, interruptions from alarms when secondary tasks were necessary to be completed, and communicating large amounts of information to large groups of people. Additionally, residents also made remarks about having difficulty sleeping and were rarely seen taking breaks.

Interview responses. When asked to recall stressful experiences during interviews, multiple stories that residents shared discussed large amounts of work to be done in short time periods, working while feeling incredibly fatigued, or a general difficulty in getting work done (see comment below).

"I didn't have a medical question though. I knew what to do in terms of the medicine it was just making it happen was so difficult. That is always the residents' responsibility: making it happen. I think

the hospitalists are there for academic questions and same with the senior residents. When you know what to do, getting it done is the hardest part.”

Acquisition of knowledge (3.2). To associate stress with the acquisition of medical knowledge node, results needed to advocate stress as the outcome of properties inherent in the purely educational aspects of learning in the healthcare environment.

Literature associations. Two articles described stress as an outcome of educational aspect of the residents’ work domain; both suggested that stress was a result of examination and evaluation (Cohen & Patten, 2005; LeBlanc & Bandeira, 2007).

Observations. One small amount of stress that pertains to this node was seen when a senior resident quizzed junior residents about ways of performing a procedure and why a patient was in the condition they were in.

Interview responses. No interview responses were found to be relevant to this node.

Acquisition of knowledge and assignments (3.25). The connection between the node beginning with "acquisition of medical knowledge" in the work functions section and the node beginning with "assignments" in the technical function section was associated with stress results that highlighted something outside of the resident required curriculum that was resulting in stress on acquiring medical knowledge.

Literature associations. Only one article was found to be mildly associated with this connection. Lister et al. (2010) highlights the difficulty imposed on surgical residents by the mandates of the Accredited Council for Graduate Medical Education, which has added additional stress to surgical residents.

Observations. No observations were found to be relevant to this connection.

Interview responses. No interview responses were found to be relevant to this node.

Technical functions. The technical functions section of the abstraction-decomposition space describes the specific function of the physical elements in the system (Lintern, 2011). Essentially, this section describes the tasks people need to perform to uphold the work functions and values/priorities of the work domain, which eventually lead to the fulfillment of the domain purpose. It is also important to keep in mind that these are the necessary tasks required to practice patient care, or acquire medical knowledge, regardless of the context. Given this definition, nodes in this section were supplemented with research results that portrayed the difficulty of some tasks necessary to be completed to practice care or acquire medical knowledge.

Monitor patients, etc. (4.1). Since the technical functions section of the abstraction-decomposition space describes the context-free tasks to be completed by resident physicians to ensure care takes place, stress was associated with this node if results explicitly identified tasks that were noted to be stressful for residents.

Literature associations. Examples of tasks that are necessary to provide patient care and were explicitly identified as being stressful in the literature review included feeling overwhelmed while retrieving emergency equipment during admissions (Baldwin et al., 1997) and rotations in the emergency department (Revicki et al., 1997).

Observations. Tasks that appeared to be stressful for residents during observations of the medical and MAT ICU included planning future procedures and medication adjustments for patients, difficulty communicating with patients who did not speak English, researching patients' history, taking notes during rounds, and filling out paperwork after admitting a patient.

Interview responses. Two interview responses indicated stress directly associated with tasks to fulfill patient care. In one instance, the resident was having issues communicating with the patient due to his accent. The second response was recorded from a resident who highlighted the difficulty of putting patients into a hypothermic protocol state.

"Just by putting them in this state they automatically have low blood pressure; so you are fighting against low and decreasing blood pressure while needing to maintain the lower body temperature. It's like the stage performer spinning with the plates on his nose and everywhere else."

Monitor patients and residents (4.151). Resident stress was associated with the connection between the "residents" node and the "monitoring patients" node, if results indicated difficulty for individual residents to adjust to the residency program or if residents encountered feeling a lack of control while in the program.

Literature associations. A considerable amount of literature was found to be associated with the connection between the "monitor patients" node and the node labeled "residents" within the abstraction-decomposition space representation. This literature included articles highlighting residents' lack of control (Thomas, 2004; Ishak et al., 2009), perceived working conditions (Panagopoulou, Montgomery, & Benos, 2006), inefficient use of time (Yao & Wright, 2000), experiencing a gap between medical school and clinical care (Luthya et al., 2004), and subjective work intensity (Biaggi et al., 2004).

Observations. No observations were found to be relevant to this connection.

Interview responses. One interview response was found to be associated with this connection. The resident mentioned experiencing a large knowledge gap when he first came to the residency from medical school, and implied that he was unfamiliar with aspects of providing clinical care.

Monitor patients and technology (4.152). To associate stress from the results of our data collection with the connection between the "monitoring patients" and the "technology" nodes, information that portrayed residents feelings of stress while using technology to carry out tasks was considered.

Literature associations. Only one article was found in the literature review that mentioned stress and the influence of technology, and this article suggested technology lowered stress for residents (Ghahramani, Lendel, Haque, & Sawruk, 2009).

Observations. Multiple observations were made that suggested residents were encountering stress from technology. For example, one resident left to find a computer to help them with rotations, and was frustrated when he couldn't find one that wasn't in use. Additionally, while inserting a catheter into a patient, a resident was seen having difficulty adjusting the table height, and had limited access to the patient due to the amount of cables and IV stands placed around the patient. Apart from this, one resident mentioned issues with a computer program that made it difficult to find information about a patient. Even the simplest of technologies seemed to impose small amounts of stress on resident physicians. For instance multiple observations were made of residents requiring at least two people to put on a smock before operating on a patient.

Interview responses. A fair amount of responses during interviews suggested the use of technology can act as a stressor to residents or reduce stress for residents. One resident mentioned the increased amount of time it takes to complete an admission using the care connect patient logging system. Another resident highlighted the importance of doing a test (example, running a CAT scan on a patient) and having immediate results can alter how the resident perceived their situation; implying that immediacy to run a test and retrieve results can lower stress for residents.

Assignments, didactic teaching sessions, participation in scholarly activities, etc. (4.2). This node is found in the technical functions section in the abstraction-decomposition space representing the residents' work domain, and describes the tasks necessary for residents to complete to acquire a deep and broad understanding of medical concepts.

Literature associations. There was a surprising lack of literature investigating how the education requirements of a residency program influence levels of stress felt by residents. This could be due to researchers over-focusing on stress as an outcome of developing skills within the medical domain, or to the inherent lack of stress associated with the tasks necessary to gain a deep understanding of medical concepts. However, the latter suggestion seems unlikely given the amount of stress frequented by people obtaining a higher education in most (if not every) domain.

Observations. No observations were found to be relevant to this connection.

Interview responses. Two residents made comments that suggested stress as an outcome of tasks necessary to fulfill the acquisition of medical knowledge in a residency program. One resident discussed stress from preparing a presentation for a noon conference held for all the residents to attend. The other resident, who was a chief resident, described a difficult situation for teaching when junior residents are being uncooperative:

"It gets bit tricky when they (first-year residents) start back-talking because you want to teach them, but you don't want to insult them or stifle their input. That would make them less likely to want to come back to you. So you need to do it in a very tactful kind of way. You need to show them why their thinking is wrong and why you are disregarding their input."

Assignments and residents (4.250). Stress was associated with the connection between the "assignments" node and the "residents" node, if results indicated residents experiencing stress as a product of aiding in the education of other residents.

Literature associations. Only two articles recognized the supervision of junior residents and medical students as a source of stress to residents (Levey, 2001; Feddock, Hoellein, Wilson, Caudill, & Griffith, 2007).

Observations. No observations were found to be relevant to this connection.

Interview responses. Two responses from resident interviews suggested stress as an outcome of shifting from a resident learner (as a third-year resident) to a resident teacher (as a chief-resident).

Assignments and attending physicians (4.251). No literature, observation, or interview associations were found relevant to this connection.

Assignments and technology (4.252). No literature, observation, or interview associations were found relevant to this connection.

Assignments and administration (4.253). No literature, observation, or interview associations were found relevant to this connection.

Physical resources. The physical resources that create a work domain are the physical devices that are relevant to the structure of the work domain being analyzed (Lintern, 2011). Since the work domain being investigated for this project was a socio-technical system, the physical resources section includes the medical support staff, technology used by resident physicians, and the administration staff. In accordance with proper abstraction-decomposition space representation etiquette, the dashed lines indicated separate identities that create the support staff, technology, or administration nodes. Also, since this analysis focused solely on residents, the node labeled “residents” that is decomposed from the support staff node, is shown as being connected to the higher levels of the representation; indicating this abstraction-decomposition space does not describe the work domain as it appears of other members of the support staff.

Support staff (5.1). To associate stress with the support staff node, results were connected if they implied stress as an outcome of collaboration or communication with groups of individuals that are members of the support staff.

Literature associations. Relevant associations to the support staff node from the literature review include resident experience issues with interpersonal relations (Ishak et al., 2009), inadequate support from professionals (Levey, 2001), not feeling respected (Luthya et al., 2004), team work issues (ElBardissi et al., 2007) and stressed interactions with colleagues (Stucky et al., 2009).

Observations. Only a couple of observations suggested stress as an outcome of collaboration with the medical support staff. In one case, a resident was misinformed that a patient was being sent to the MICU, so he began preparing to accept the patient, only to receive another call cancelling the transfer. Another observation was made that a resident was having difficulty coordinating which labs were being ordered for a patient and why the patient needed adjustments made to his medication.

Interview responses. No interview responses were found to be relevant to this node.

Residents (5.1.1). Results from residents or the literature that indicated stress as the lack of competency or a general unfamiliarity with the residency domain were associated with the resident node that was decomposed from the support staff node.

Literature associations. Three articles from the literature review were found to be associated with the resident node, and highlighted stressors such as lack of theoretical knowledge (Luthya et al., 2004), insufficient medical knowledge, and poor clinical judgment (Yao & Wright, 2000).

Observations. No observations were found to be relevant to this connection.

Interview responses. A large number of residents identified stress due to the lack of familiarity with the hospital or the resident domain by recalling stories of stressful experiences during their first year in the program. Specifically, residents identified not knowing what to do when a patient is crashing, not knowing what is going on with a patient in terms of diagnosis, and not knowing how to access the resources to solve the previous issues, was particularly stressful.

Attending physicians (5.1.2). Results from the literature review, observations, and interviews were associated with the “attending physicians” node if the resident or literature specifically identified attending physicians as a source of stress to resident work.

Literature associations. No literature associations were found to be relevant to this node.

Observations. Observations in the medical and MAT ICU that suggested interacting with attending physicians as a source of stress for residents were few and far between. One instance was noted when an attending physician lightly scolded a junior resident for administering an unnecessary medication to a patient. Another instance was noted when an attending physician was upset about a patient being sent home when he shouldn’t have, but this issue mostly involved emergency room personnel, and was not targeted at residents.

Interview responses. Responses from resident physician interviews suggested attending physicians to be a source of stress for residents, or an anticipated source of stress for one resident who hadn't encountered any issue with the attending physicians. Specifically, one resident mentioned a brief argument that took place between an attending and a resident on whether a patient needed to head to the operating room or not.

Medical students (5.1.3). No literature, observation, or interview associations were found relevant to this connection.

Physicians' assistants (5.1.4). Results from our data that suggest stress as an outcome of direct collaboration with a physicians' assistant was associated with this node.

Literature associations. No literature associations were found to be relevant to this node.

Observations. No observations were found to be relevant to this connection.

Interview responses. During the interviews with resident physicians, one resident recalled a stressful situation that was the result of a dispute with a physicians' assistant. Basically, the resident believed the PA was practicing poor medical judgment and refused to take the resident's advice until much later in the day.

Nurses (5.1.5). Data collected from the literature review, observations, interviews and surveys that suggested stress as a result of working with the nursing staff was associated to this node.

Literature associations. No literature associations were found to be relevant to this node.

Observations. No observations were found to be relevant to this connection.

Interview responses. During interviews, one resident identified a stressful situation that stemmed from collaboration with the nursing staff. Specifically, this resident recalled encountering multiple misunderstandings with nursing personnel that was making it difficult to collaborate with them.

Nodes without associations. The nodes for technology (5.2), administration (5.3), and all the levels decomposed from these nodes including life support systems (5.2.1), communication systems (5.2.2), patient record systems (5.2.3), ACGME representatives (5.3.1), and program overseers (5.3.2) were found to have no relevant associations made to them within the resident stress literature, during observations, or interviews. The lack of associations to these nodes likely stems from the analysis focusing only on how aspects of the work domain directly interact with one another to create stress within residents' work. Although each of the elements in the physical resources eventually manifests within the residents' work domain, looking for relevant stress literature and investigating the amount of stress caused by each node in this section of the abstraction-decomposition space would likely have a small impact on understanding how stress forms within a residency program as a whole.

Survey Results

A total of 44 residents out of the 63 in the program responded to the survey. One respondent was excluded from analysis due to a lack of answering any questions beyond the first in the survey. For the remainder of residents, the average age was 31, and the sample consisted of 21 females and 22 males. Basic demographics and response rates for the residents are provided in Table 1.

Table 1

Basic demographic Information for the Likert Scale Question Results

Characteristic	Frequency	%	Total residents in program	Response rate
Total Sample	43	—	60	68%
Year of Residency				
1 st year	10	23%	19	53%
2 nd year	14	32%	19	74%
3 rd year	16	37%	21	76%
4 th year	2	>1%	4	50%
Gender				
Female	21	49%		
Male	22	51%		

Within the survey, statements were created from resident stress literature and interview associations made to the abstraction-decomposition space depicting the residents' work domain to collect responses from resident physicians inquiring which function of the work domain were perceived as stressful. The statement that was made for residents to agree or disagree with, the association of the statement to the abstraction-decomposition space, and the median response to each question is provided in Table 2.

Table 2

Median Responses and the Abstraction-Decomposition Space Associations to Likert Scale Questions

Likert Scale Question	Abstraction-Decomposition Space Association	Median response (1=Strongly disagree; 5=Strongly agree)
I find the program directors or ACGME overseers to be a significant source of stress in my usual work day.	5.3 Administration	2 (Disagree)
I find technology to be a significant source of stress in my usual work day.	5.2 Technology	2 (Disagree)
I find the acquisition of the skills required to practice medicine to be a significant source of stress in my usual work day.	2.1 - 3.1 "Practicing care"	3 (Neutral)
I find developing a deeper understanding of medical concepts to be a significant source of stress in my usual work day.	2.3 - 3.2 Acquisition of knowledge	3 (Neutral)
I have found feelings of role ambiguity (being a physician vs a student) to be a significant source of stress during my usual day.	1.1 Create competent doctors	4 (Agree)
I find the insecurity of my understanding of medical concepts to be a significant source of stress in my usual work day.	5.1.1 Residents	4 (Agree)
I find the number of tasks necessary to care for patients to be a significant source of stress in my usual work day.	3.15 Means-end between "Practicing care" and Monitor patients	4 (Agree)
I find the number of scholarly activities necessary to gain in-depth knowledge about medical concepts to be a significant source of stress in my usual day.	3.25 Means-end between Acquisition of knowledge and Assignments	4 (Agree)

Table 2 (continued)

Likert Scale Question	Abstraction-Decomposition	Median response (1=Strongly disagree; 5=Strongly agree)
	Space Association	
I find the difficulty of performing some tasks necessary to fulfill the educational requirements of the residency program at RGH (assignments, participation in scholarly activities, studying medical literature, etc.) to be a significant source of stress in my usual day.	4.2 Assignments	4 (Agree)
I find the difficulty of performing some tasks necessary to provide care to patients (monitoring patients, ordering labs, ordering medications, participating in and observing procedures, etc.) to be a significant source of stress in my usual day.	4.1 Monitor patients	3 (Neutral)

After collecting all the data from the survey, one resident mentioned difficulty getting the ranking section of the online survey to work. Because of this issue, data from 13 participants were excluded from the analysis of the ranking section in the survey. Data were considered justifiable to exclude from analysis if no change was made to the order of the ranking list when the resident submitted the survey. Demographic information for the residents included in the analysis of the ranking question is included in Table 3. Medians for the remaining 30 resident survey responses were analyzed, and then the ranking list was reassembled to show which groups of people residents experienced the most stress working with in the hospital. The ranking list, reorder to show residents' responses, is shown in Table 4 with the median score for each working group.

Table 3

Basic Demographic Information for Ranking Question Results

Characteristic	Frequency	%	Total residents in program	Response rate
Total Sample	30	-	63	47%
Year of residency				
1st year	6	20%	19	32%
2nd year	10	33%	19	53%
3rd year	11	37%	21	37%
4th year	2	7%	4	50%
Gender				
Female	14	47%		
Male	16	53%		

Table 4

Reconstructed List of Stressful Work Groups According to Median Results

Stress rank	Working group	Median Score
Most stressful	Attending physicians	2
	Chief residents	2
	Administration	4
	Nursing staff	4
	2nd year residents	5
	1st year residents	6
	3rd year residents	6
	Physician assistants	8
	Medical students	8
Least stressful	Pharmacists	8.5

Correlation. A pairwise correlation using Spearman's rho was run on all 43 responses to Likert scale questions to determine if any relationship existed between variables.

Multiple correlations emerged from the pairwise test (see Table 5). Among these correlations, three strong positive correlations were found and are displayed graphically (see Figures 4, 5, and 6). Given the lack of the same answers being shown multiple times on the scatterplot, a line of best fit was provided to aid in the appraisal of each correlation.

The first relationship emerged between the agreeableness of stress resulting from a lack of competency and the agreeableness of stress resulting from the development of a deep and broad understanding of medical concepts ($r(3872) = .71, p < .001$) and is shown in Figure 3. The second relationship discovered was between residents' responses to the agreeableness of stress being a result of the development of a deep understanding of medical concepts to the agreeableness that stress was a result when acquiring skills necessary to apply medical knowledge ($rs(4039) = .69, p < .001$)(see Figure 4). The third strong correlation that emerged from residents' response to Likert scale questions was a relationship between the agreed response that a lack of competency resulted in stress to the agreed response that acquiring skills necessary to apply medical knowledge results in stress ($rs(4362) = .67, p < .001$) (see Figure 5).

Table 5

Pairwise Correlation Results for Likert Scale Responses using Spearman's Rho

Identified Stressor	Age	Year	Administration	Technology	Acquire Skills	Develop Knowledge	Create Physicians	Competency	Number of Tasks (care)	Number of Tasks (education)	Perform Tasks (education)	Perform Tasks (care)
Age	-	0.685			-0.220	-0.329	-0.270	-0.316				
Year	0.685	-						-0.268				
Administration			-		0.298					0.398	0.471	0.232
Technology				-		0.257						0.288
Acquire Skills	-0.220		0.298		-	*0.694	0.364	*0.670		*0.546	*0.525	*0.589
Develop Knowledge	-0.329			0.257	*0.694	-	*0.571	*0.707	0.200	*0.516	0.271	0.456
Create Physicians	-0.270				0.364	*0.571	-	0.462	0.325	0.329		
Competency	-0.316	-			*0.670	*0.707	0.462	-	0.207	0.411		0.421
		0.268										
Number of Tasks (care)						0.200	0.325	0.207	-	0.363		0.221
Number of Tasks (education)			0.398		*0.546	*0.516	0.329	0.411	0.363	-	*0.637	0.469
Perform Tasks (education)			0.471		*0.525	0.271				0.637	-	0.372
Perform Tasks (care)			0.232	0.288	*0.589	0.456		0.421	0.221	0.469	0.372	-

Note. Only results above $r = .2$ were included in the matrix. Additionally, perfect correlations between an item with itself were replaced with a dash (-).
 * $p < .01$

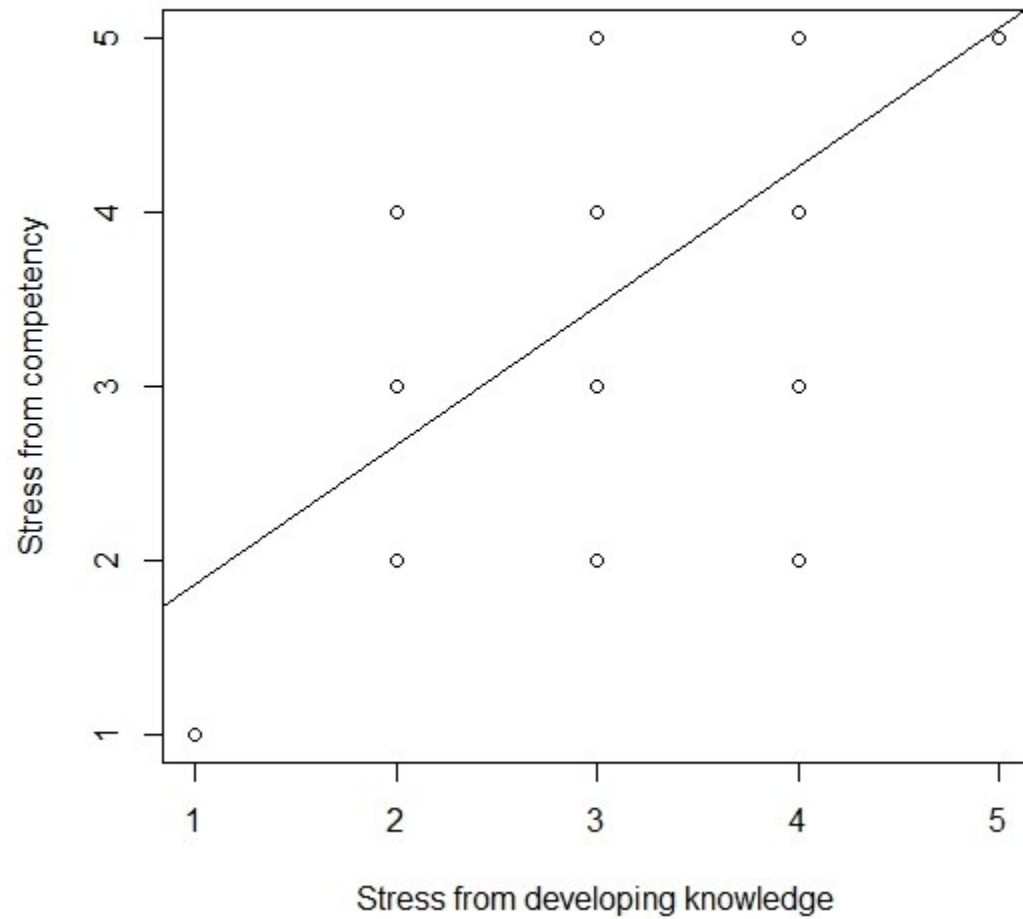


Figure 3. This graph shows the relationship between resident reports of agreeableness that stress is a result of a lack of competency, to resident reports of the agreeableness that developing knowledge is a source of stress.

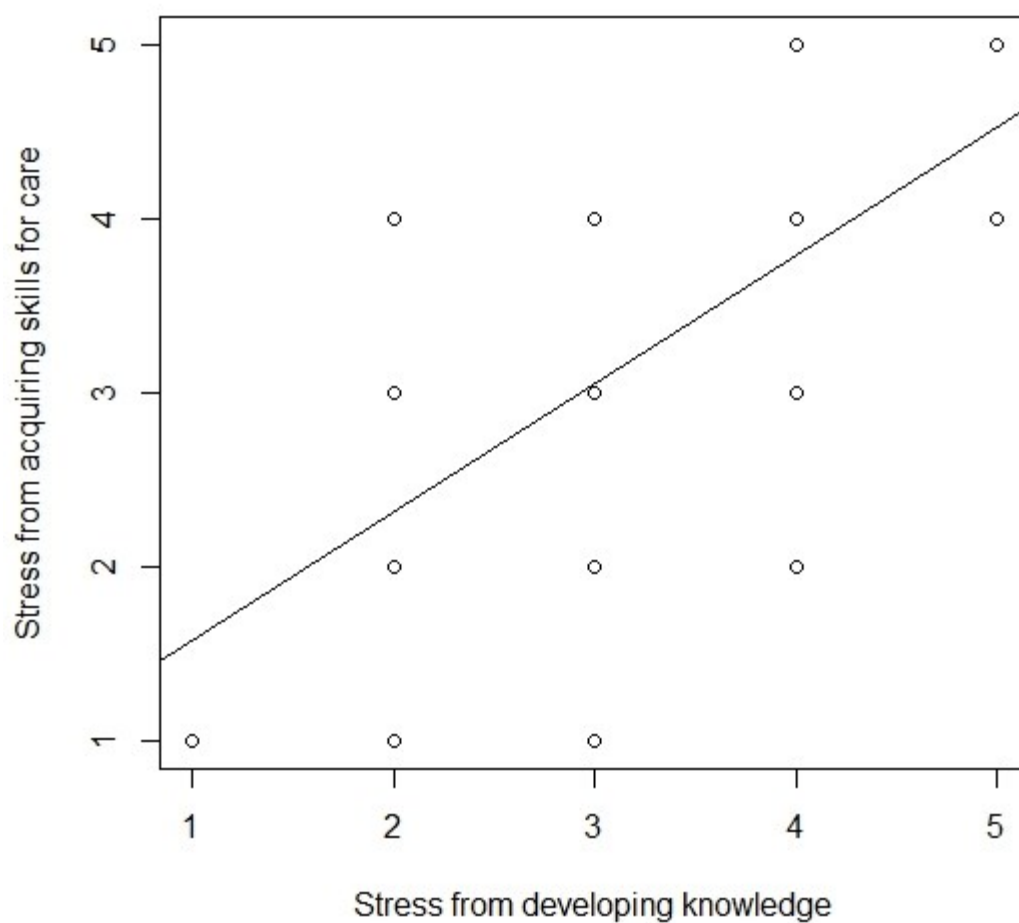


Figure 4. This graph shows the relationship between resident reports of agreeableness that stress is a result of developing a deep understanding of medical concepts, to resident reports that acquiring medical skills to apply medical knowledge is a source of stress.

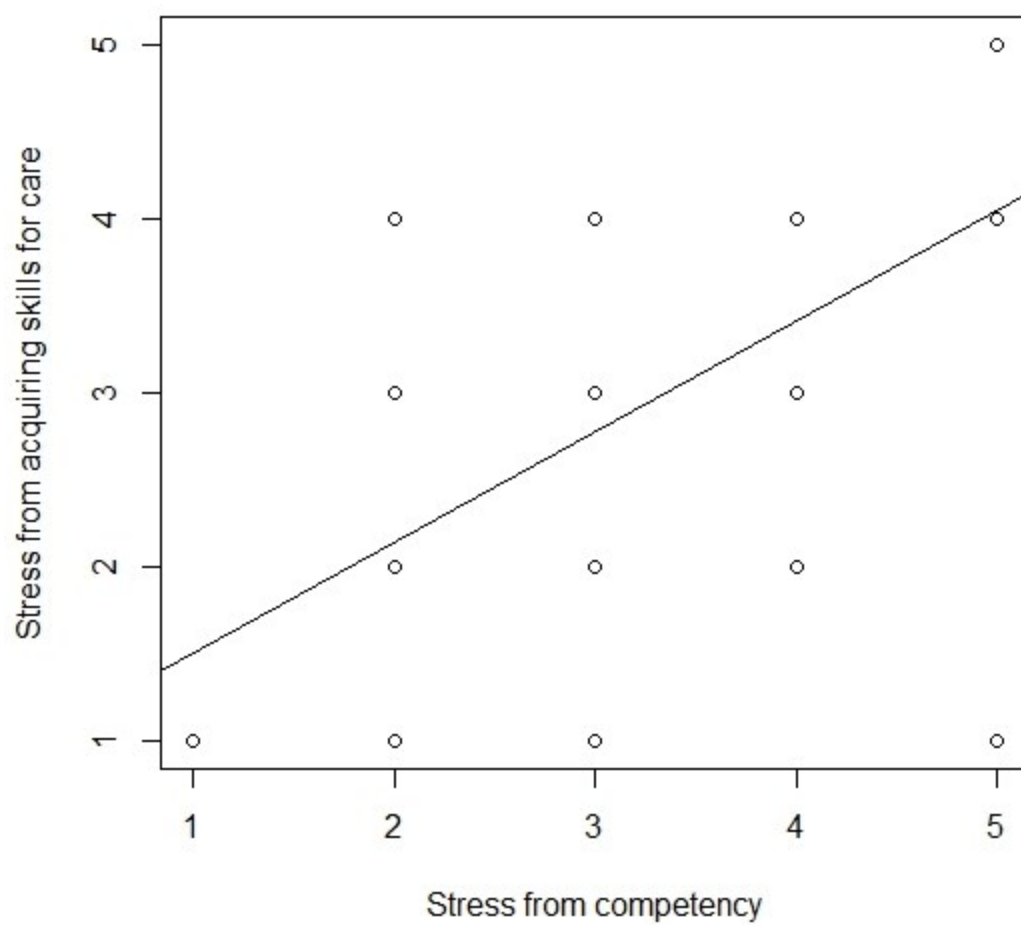


Figure 5. This graph shows the relationship between resident reports of agreeableness that stress is a result of competency, to resident reports of the agreeableness that acquiring medical skills to apply medical knowledge is a source of stress.

Additional correlation results were found to be significant including relationships between: the amount of stress agreed to be stemming from the difficulty of tasks necessary to be completed to acquire medical knowledge, to the agreed outcome that stress was a result of the number of tasks to be performed in order to gain medical knowledge ($r = .64, p < .001$); the amount of stress agreed to be from the difficulty of tasks to be completed to acquire medical knowledge, to the agreed stress that the number of tasks required to acquire medical skills to apply medical knowledge ($r = .55, p < .001$); the number of tasks to be performed in order to gain medical knowledge, to the agreed stress that the number of tasks required to acquire medical skills to apply medical knowledge ($r = .53, p < .001$); the amount of stress agreed to be from the difficulty of tasks necessary to provide care to patients, to the agreed stress that the number of tasks required to acquire medical skills to apply medical knowledge ($r = .59, p < .001$); the agreed outcome that stress stems from perceptions of role ambiguity, to the agreed outcome that stress stems from the development of knowledge towards medical concepts ($r = .57, p < .001$); and the agreed outcome that stress stems from the development of knowledge towards medical concepts, to the amount of stress agreed to be from the difficulty of tasks to be completed to acquire medical knowledge ($r = .52, p < .001$) (see Table 4) (For graphs of these data, see Appendix D.)

Discussion

Results obtained from the resident stress literature associations to the abstraction-decomposition space created in this research suggest there is a lack of published research investigating how stress interacts with the development of a deep and broad understanding of medical concepts. This gap in research begins with node 2.3, titled the “development of depth and breadth of medical knowledge”, and follows all the connections and nodes through to the “assignments, didactic teaching session, etc.” (node 4.2) on the right side of Figure 1. In total, only 5 articles discussing 7 sources of stress were found to be associated with this portion of the work domain. The few stressors that were found to be associated with this section of the resident work domain included sources describing the learning environment (Levey, 2001; Tyssen et al., 2005) associated with node 2.3, pedagogical methods (Lister et al., 2010) associated to connection 3.25 that falls between the “development of knowledge” node and the “acquisition of medical knowledge node”, and the supervision of junior residents (Levey, 2001; Feddock et al., 2007) that was associated to connection 4.250 between the “assignments, didactic teaching sessions, etc.” node and the “residents” node located near the physical resources space. In comparison, on the left side of Figure 1 under the “application of medical knowledge” node starting at 2.1 and running down the representation to the “monitoring patients, ordering medications, etc.” at node 4.1, is the largest amount of published stress research within the residents’ work domain; totaling 27 articles and 38 separate sources of stress. Stress literature associations that were made with nodes and connections in this section of the residents work domain include variants of time pressure (Adler et al., 1980; Cohen & Patten, 2005), insufficient sleep (Levey, 2001; Cohen & Patten, 2005), and excessive workload (Levey, 2001; Biaggi et al., 2004; Luthya et al., 2004; Cohen & Patten, 2005) associated to connection 3.15 between the “monitoring patients, ordering medications, etc.” node and the “practicing care” node. Additionally, stressors associated with tasks considered stressful by resident physicians (Baldwin et al., 1997, and Revicki et al. 1997) were associated to node 4.1, and stress as the product of making mistakes (Sexton et

al., 2000; Wu, 2000; ElBardissi et al., 2007) was associated to node 3.1 for the misapplication of “practicing care”.

This result suggests stress research has become overly focused on investigating the sources of stress that manifest when residents apply medical knowledge, and has neglected to investigate sources of stress for residents as they develop a deep and broad medical knowledge. As indicated by the results of the survey (see Table 2), the difficulty of performing tasks to acquire medical knowledge and the number of tasks necessary to gain in-depth medical knowledge were both identified as significant sources of stress to residents. This suggests stress does reside in the educational aspects of residents’ work, and offers an invitation for future research to further explore stress in the development of a deep and broad understanding of medical concepts in the residents’ work domain.

Apart from helping to identify where stress has been researched in the residents’ work domain, the abstraction-decomposition space with literature associations can also be used to help standardize how the term stress is used within resident literature. Given the lack of a definition for stress in a large number of articles investigating resident stress, the validity of comparisons made between articles is questionable. By associating each literature article with a node or connection within the abstraction-decomposition space representation, the assumption made about the definition of stress when comparing two articles that are associated to the same node of a work domain, should be considerably smaller than assumptions made about stress being defined as a general term that encompasses all areas of the work domain. For example, work overload (Luthya et al., 2004), total patient load (Stucky et al., 2009), and time pressure (Buddeberg-Fischer et al., 2008) were all associated to connection 3.15 between the nodes of “practicing care” and “monitoring patients, etc” node in the abstraction-decomposition space (Figure 1). However, none of these authors give an explicit definition for what stress is. By tying these stressors together with the common association to node 3.15 of the abstraction-decomposition space, we can more safely come to a conclusion that the work overload stressor Luthya, Perrier, Perrin, Cedraschi, and Allaz (2004) described is similar to the total patient load stressor described by Stucky et al. (2009). Additionally, we

can make a safer assumption that each of the previously mentioned stressors is more related to stress from time pressure described by Buddeberg-Fischer, Klaghofer, Stamm, Siegrist, and Buddeberg (2008) than to sources of stress outside of the 3.15 connection; such as stress experienced by the number of patient deaths (Baldwin et al., 1997) that is associated to connection 2.15 between the “skillful application of medical knowledge” and the “practicing care” nodes in Figure 1. Doing this still does not offer a distinct definition for stress within each article, but it does help create a more informed guess to how each author may have been defining stress and offer an idea of the weight of an assumption made between articles discussing stress in the residents’ work domain.

Stress at the Hospital

The same technique used to associate resident stress literature to the abstraction-decomposition space was also used to draw conclusions about stress in the residency program being studied. Associating observation, interview, and survey results to relevant connections in the abstraction-decomposition space representing the residents work domain allowed us to see where stress was occurring in the residency program. Figure 2 provides the frequency of each stressor defined by the method of data collection and shown next to the node or connection of the representation of the residents work domain (Figure 1), and should be referenced when interpreting the following results.

Observations. A large amount of stress was witnessed when residents were using technology (connection 4.152), performing tasks (node 4.1), experiencing information overload or time pressure (connection 3.15), and when encountering difficult job situations such as working with family members in the room (connection 2.15). However, it is important to acknowledge the assumptions made when noting specific tasks or occurrences as stressing. One situation or task that might appear stressful to the researcher conducting the observations may in fact be simple and relatively un-stressing to the individual being observed.

Interviews. Interview responses that were associated with the abstraction-decomposition space representing the residents’ work domain suggest the main sources of stress for residents in the hospital

were the result of responsibility towards taking care of patients (connection 1.151), difficulties present in the dependency of learning while practicing patient care (node 2.2), encountering difficult job situations (connection 2.15), working under time pressure or under heavy workload (connection 3.15), and issues with residents' perception of their own competency (node 5.1.1). By taking both observation notes and interview responses into consideration, the main sources of stress affecting residents appears to extend from the responsibility towards taking care of patients (connection 1.151), encountering difficult job situations (connection 2.15), working with time pressure or heavy workload (connection 3.15), using technology (connection 4.152), and difficulty performing some tasks (node 4.1).

Survey. The observation and interview results of this study conform to previous literature investigating resident stress (Revicki et al., 1997; Levey. 2001; Cohen & Patten, 2005; Buddeberg-Fischer et al., 2008). Survey results also conformed to previous literature, suggesting significant stress is imposed on residents when practicing multiple tasks to provide patients with care (connection 3.15), from encountering feelings of role ambiguity (node 1.1), and suffering from issues associated with self-perceived competency (node 5.1.1). Survey results also found significant sources of stress to reside in the under-researched development of medical knowledge branch of the resident's work domain; specifically in the amount of tasks required to acquire medical knowledge (connection 3.25) and the difficulty of performing some tasks to acquire medical knowledge (node 4.2).

Results from the ranking section of the survey suggest the most stressful group of people to work with for residents are attending physicians, followed by chief residents, administration, nursing staff, then second and first year residents (see Table 4). Given the demographics of the population sampled, after contaminated responses were removed, this result is to be expected since the majority of residents who finished this portion of the survey were second and third year residents (See Table 3). Second and third year residents work under attending physicians and chief residents, and do not have a large amount of administrative responsibility, which might explain the results obtained in this section of the survey.

Correlations. Results from correlations suggest stress from the development of deeper medical knowledge is strongly related to the amount of stress stemming from residents' self-perceived competence (see Figure 3). This result seems intuitive. For example, if an individual perceives themselves as highly incompetent in a specific domain of knowledge, it makes sense that the individual would likely feel intimidated by the tasks and situations necessary to develop this area of knowledge.

In addition to this result, stress from the development of a deeper understanding of medical concepts and stress experienced from the acquisition of skills necessary to apply medical knowledge was found to be strongly correlated (see Figure 4). This relationship is suggestive of the well-known service/education conflict (Wartman et al., 1990). Wartman et al. (1990) highlighted the difficulty of identifying which activities are considered service and which activities are considered education within a residency program, and argued that this conflict creates a barrier to implementing changes within residency programs. As suggested by the correlation between stress from the development of medical knowledge and stress from the application of medical skills, stress seems to be associated with each side of this conflict. However, given the structure of the work domain and the associations of stressors provided in this study, this may offer ideas for how activities can be grouped to determine which activities make up service or education, and also determine which activities include both educational and service aspects.

The final strong correlation discovered in the analysis of the survey results was the positive relationship between stress from residents' self-perceived competence and the acquisition of skills necessary to practice medical knowledge (Figure 5). Given the previous correlation suggested stress from perceived competence has strong ties to stress in the development of medical knowledge; perceived competence could act as a catalyst for the amount of stress experienced throughout the entire resident work domain. However, further research is needed to investigate the relationship between competency and stress as it pertains to residents work.

Limitations

Given the novel constitution of this work, the greatest limitation is the subjective nature in which the abstraction-decomposition space is created and the stress associations to nodes and connections within the representation are made. Because our application of the abstraction-decomposition space as an organizational structure for literature and results from qualitative data collection is completely novel, no comparisons exist to judge the correctness of this approach. Future research should focus on developing methods to test the correctness of these associations, or replicate literature and result associations to domain representations in different domains.

Additionally, observation and interview data was collected while the abstraction-decomposition space representation was being completed, and only in the MICU and MAT ICU areas of the hospital. This limited the extent to observe residents encountering stress while pursuing the development of medical knowledge, and resulted in our initial focus of this study to investigate stress as it pertains to the application of medical knowledge. Future research should replicate this study but include a more thorough investigation of resident stress in each area of the residents' work domain for an even more holistic understanding of resident stress.

Implications

This research is highly applicable to the design of residency programs. By conducting a work domain analysis for the residency program at a local hospital and creating an abstraction-decomposition space to describe the residents work domain, program designers and systems engineers can use this representation to see how the work domain is structured. As previously mentioned, Hajdukiewicz et al. (2001) explain how the abstraction-decomposition space they created for surgeons became a reference point for sharing information across the operative team and in the development of informatics systems. Similar to Hajdukiewicz et al.'s (2001) result, the representation created in the current study can also provide a frame of reference for program coordinators, residents, and physicians to discuss points of interest in the work domain and anticipate how new regulations might affect the resident work domain.

Aside from the applicability of the abstraction-decomposition space by itself, associating the results of stress inquiries and literature to relevant nodes and connections within the representation creates a new form of abstraction-decomposition space that offers a map to help researchers and physicians gain a better understanding of the amount of stress encountered by resident physicians, where the stress is manifesting within the work domain, and how stress manifests itself within residents work.

Using the abstraction-decomposition space representation with stress associations to gain a better understanding of resident stress on a more holistic level can provide implications for the development of programs to mitigate excessive stress on residents. In recent years, general approaches to the reduction of stress through coping mechanisms are ill-advised (Hemingway & Smith, 1997). Coping mechanisms developed in a general manner likely reduce stress in isolated incidences, or provide support through certain stressful situations, but may not apply to incidents or situations outside of the circumstance they were developed for. By using the abstraction-decomposition space representing the residents' work domain, and accounting for where stress occurs within the work domain, the development of coping methods that extend beyond the impact of specific occurrences could be possible. In addition to aiding in the development of new coping methods for stress, providing the stress associations in the abstraction-decomposition space creates an alternative method to reducing resident stress by acting as a tool to help consider ways of altering the residents' work domain to reduce resident stress.

Conclusion

The novel application of the abstraction-decomposition space to organize resident stress literature, observations, interviews, and surveys provides an interesting artifact to aid in the design and development of residency programs. This technique also provides a frame of reference for program coordinators and physicians to communicate about residents' work and can be used as an aid in the development of methods to mitigate resident stress by accounting for the work domain when developing mitigation methods, or restructuring residents work to reduce excessive stress in the targeted area of the work domain.

Although this research did not uncover a steadfast definition for stress, the technique used to analyze the construct of stress as it associates to the work domain can provide insight to the permeability of stress within a domain, provide researchers with a sense of variety for possible definitions for stress in the domain literature, and lessen the extent of the assumptions made when comparing articles investigating resident stress that share the same work domain node or connection association. Future work should focus on replicating the technique developed in this study in different domains, investigate ways to test the strength of result associations to work domain nodes and connections, and focus on providing a more thorough replication of this study that includes observation and interview data collected from each section of the residents' work domain.

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